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Dielectric permittivity enhancement by formation of charged domain walls in stoichiometric lithium niobate

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In the recent years, a growing attention is paid to the modification of the properties of the ferroelectric materials by the charged domain wall (CDW) engineering. These intrinsic interfaces are considered as an alternative to the conventional chemical doping to achieve the nanoscale tailored structure. Currently, the influence of CDWs on the conductivity [1, 2] and piezoelectric coefficient [3] has been revealed. The dielectric properties can be effectively improved by formation of the domain structures with the high concentration of CDWs [4]. Two mechanisms of this effect have been considered: the motion of domain walls under applied electric field and stationary contribution that arises irrespective of any lateral displacement of the wall.

We have revealed the significant increase of low-frequency dielectric permittivity of the stoichiometric lithium niobate (SLN) as a result of CDW formation. The self-assembled structure consisting of spike-like domains with CDWs was formed during the polarization reversal at 145 °C by application of the rectangular high field pulse using uniform metal electrodes. The electrical impedance was measured in the frequency range 10 Hz-100 kHz immediately after polarization reversal. The dielectric permittivity has increased up to one order of magnitude at the lowest frequencies, whereas no changes were observed at frequencies above 10 kHz. The created increase of the dielectric permittivity relaxes to the single domain state value. The acceleration of this relaxation by application of the DC bias has been revealed.

The effect of dielectric permittivity enhancement has been attributed to the vibration of the individual steps on the CDW. Slow bulk screening of the depolarization fields leads to stabilization of the steps and decrease of the dielectric response. Acceleration of the relaxation under DC bias was attributed to intensification of the stabilization process.

The presented effect can be used for increasing of dielectric permittivity by the formation of CDWs. The creation, displacement and erase of CDWs [5] provide a route to develop new nanoelectronic devices.

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